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OF

Jon William Dukes
Rickie Anthony Pendergrass
Drew Leo Platts
Jairo Luiz Soares

FOR

GAS PRESSURE DRIVEN FLUID PUMP HAVING COMPRESSION SPRING PIVOT MECHANISM AND DAMPING SYSTEM

GAS PRESSURE DRIVEN FLUID PUMP HAVING COMPRESSION SPRING PIVOT MECHANISM AND DAMPING SYSTEM

Priority Claim

[0001] This application claims priority to Provisional Application No. 60/433,315, filed on December 13, 2002, which is hereby incorporated by reference.

Background

[0002] The present invention relates generally to gas pressure driven fluid pumps. More particularly, the invention relates to such a pump utilizing a compression spring linkage to selectively open and close gas ports in a snap acting manner.

[0003] Condensate removal systems in steam piping arrangements often utilize gas pressure driven pumps that function without electrical power. As described in U.S. Patent No. 5,938,409 to Radle (incorporated herein by reference), such a pump typically will have a tank with a liquid inlet and a liquid outlet. The liquid inlet and liquid outlet, which are located near the bottom of the tank, will be equipped with an inlet

check valve and an outlet check valve to permit liquid flow only in the pumping direction. A pair of interconnected valves control a gas motive port and a gas exhaust port.

[0004] The pump operates by alternating between a liquid filling phase and a liquid discharge phase. During the liquid filling phase, the motive port is closed while the exhaust port is open. A float connected to a snap acting linkage rises with the level of liquid entering the tank. When the float reaches a high level position, the linkage snaps over to simultaneously open the motive port and close the exhaust port. As a result, the pump will switch to the liquid discharge phase.

[0005] In the liquid discharge phase, steam or other motive gas is introduced into the pump tank through the motive port. The motive gas forces liquid from the tank, thus causing the float to lower with the level of the liquid. When the float reaches a low level position, the linkage snaps over to simultaneously open the exhaust port and close the motive port. As a result, the pump will again be in the liquid filling phase.

[0006] While the snap acting linkage used in gas pressure driven pumps of the prior art generally has functioned well, there exists room in the art for additional snap acting valve arrangements.

Summary of the Invention

[0007] The present invention recognizes and addresses the foregoing considerations, and others, of prior art constructions and methods.

[0008] In one aspect, the invention provides a gas pressure driven fluid pump. The pump comprises a pump tank having a liquid inlet and a liquid outlet. A float member carried within the interior of the tank moves between a low level position and a high level position.

[0009] A compression spring is provided with a first end operatively connected to the float member. A pivot member is operatively connected to the second end of the compression spring. The pivot member rotates to a first position in a snap-over manner when the float member reaches its high level position due to the force applied by the compression spring. The pivot member rotates to a second position in a snap-over manner when the float member reaches its low

level position due to the force applied by the compression spring.

[0010] A valve assembly is connected to the pivot member. The valve assembly is switchable between motive porting and exhaust porting in a snap over fashion due to rotation of the pivot member between its first and second positions. The valve assembly moves to motive porting when the pivot member snaps-over to its first position and to exhaust porting when the pivot member snaps-over to its second position such that liquid will be alternately introduced into and discharged from the pump tank.

[0011] In another aspect of the invention, the pump contains a damping system operatively connected to the pivot member. The damping system slows movement of the valve assembly to reduce impact forces opening and closing valves. As a result, impact damage on the valves' sealing surfaces is largely eliminated and the sound level of the pump is reduced.

[0012] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one or more embodiments of

the invention and, together with the description, serve to explain the principles of the invention.

Brief Description of the Drawings

[0013] A full and enabling disclosure of the present invention, including the best mode thereof to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, which makes reference to the accompanying drawings, in which:

[0014] Figure 1 is a rear cross-sectional view of the pump housing with the float in the high level position;

[0015] Figure 2 is a view similar to Figure 1 with the float in the low level position;

[0016] Figure 3 is a schematic diagram of the valve assembly and compression spring pivot mechanism in accordance with one embodiment of the present invention;

[0017] Figure 4 is a front perspective view of the compression spring pivot mechanism of Figure 1 with the float in the low level position;

[0018] Figure 5 is a view similar to Figure 4 with the float in the high level position;

[0019] Figure 6 is a detailed side cross-sectional view of the compression spring linkage along line 6-6 of Figure 1;

[0020] Figure 7 is a detailed side cross-sectional view of the compression spring linkage along line 7-7 of Figure 2;

[0021] Figure 8 is a top plan view of the compression spring pivot mechanism of Figure 1;

[0022] Figure 9 is a rear perspective view of the compression spring pivot mechanism of Figure 1 with the float in the low level position;

[0023] Figure 10 is a side view of the compression spring pivot mechanism of Figure 1 with the float in the low level position;

[0024] Figure 11 is a detailed side view of the compression spring linkage mechanism (partially in section) with the float in the low level position;

[0025] Figure 12 is a detailed side view similar to Figure 11 with the float in the high level position;

[0026] Figure 13 is a detailed view of the pivotal connection between the compression spring and pivot member;

[0027] Figure 14 is a detailed side view similar to Figure 11 but showing an alternative connection between the float and the compression spring;

[0028] Figure 15 is a schematic diagram of an alternative embodiment of the compression spring pivot mechanism;

[0029] Figure 16 is a detailed top view, partially in section, showing the pivotal connection between the compression spring and pivot member in accordance with an alternative embodiment;

[0030] Figure 17 is a detailed side cross-sectional view of the pivotal connection between the compression spring and pivot member along line 17-17 of Figure 16;

[0031] Figure 18 is a detailed top cross-sectional view of the compression spring linkage mechanism in accordance with the embodiment of Figure 16;

[0032] Figure 19 is a detailed side cross-sectional view of the tip portion of the pivot member and the anchor in accordance with exemplary embodiments;

[0033] Figure 20 is a detailed side cross-sectional view of the tip portion of the pivot element and the bushing in accordance with exemplary embodiments;

[0034] Figure 21 is a detailed side cross-section view of an exemplary valve having a hardened metallic alloy on its valve seat according of an embodiment of the present invention; and

[0035] Figure 22 shows an articulated connection between float and float arms according to an embodiment of the present invention.

[0036] Repeat use of reference characters in the present specification and drawings is intended to represent same or analogous features or elements of the invention.

Detailed Description of the Preferred Embodiments

[0037] Reference will now be made in detail to presently preferred embodiments of the invention, one or more examples of which are illustrated in the accompanying drawings. Each example is provided by way of explanation of the invention, not limitation of the invention.

[0038] Figures 1 and 2 illustrate a pressure driven pump 10 constructed in accordance with the present invention. As shown, pump 10 has a tank 12 defining an interior in which a float 14 is located. Float 14 may be pressurized, thereby increasing buoyancy and

lowering its weight. Such a pressurized float may advantageously prevent collapse under high pressure or water hammer.

[0039] Referring now also to Figure 3, float 14 is rigidly connected to a pair of float arms 16 that are pivotally attached to a support frame 18. A spud 20, also connected to float 14, is operatively connected to one end of a compression spring 22. Although spud 20 is rigidly connected to float 14 and float arms 16 in the embodiment shown, it should be appreciated that the connection between float 14 and float arms 16 could be articulated as shown in Figure 22 and described below to allow some free movement of float 14.

[0040] The opposite end of compression spring 22 is pivotally connected to a pivot member 24 controlling a push rod 44. In turn, push rod 44 is connected to a valve assembly 26. Valve assembly 26 controls the operation of a motive valve 28 and an exhaust valve 30.

[0041] Valves 28 and 30, respectively, function to introduce motive gas into and exhaust gas out of the interior of tank 12 based on the position of float 14.

Toward this end, a motive pipe 32 is connected between motive valve 28 and a source of motive gas, such as a source of steam. Similarly, a balance pipe 34 is connected between exhaust valve 30 and a suitable sink to which gas inside of tank 12 can be exhausted. In some cases, for example, balance pipe 34 can terminate such that the gas will simply exhaust to the ambient atmosphere.

[0042] In one embodiment, valves 28 and 30 have a suitable alloy formed on each valve seat to increase durability. For example, a product sold under the name STELLITE by Stoody Deloro Stellite, Inc. of St. Louis, Missouri, would be a suitable alloy for the seats of valves 28 and 30. In Figure 21, for example, an embodiment of motive valve 28 having a valve stem 29 that contacts a seat 31 formed from a hard metallic alloy is shown.

[0043] As shown in Figures 1 and 2, tank 12 defines a liquid inlet 36 through which the liquid to be pumped is introduced. Tank 12 further defines a liquid outlet 38 through which the liquid passes when pumped into return line 40. Respective check valves 41 and 42 are provided at liquid inlet 36 and liquid

outlet 38 so that the liquid flows in only the desired direction.

[0044] When tank 12 is emptied, float 14 will fall to the low level position shown in Figure 2. Upon reaching the low level position, force from compression spring 22 rotates pivot member 24 in a snap over manner to its exhaust position. In other words, the rotation of pivot member 24 moves push rod 44 to simultaneously switch motive valve 28 and exhaust valve 30 in a snap over manner from motive porting to exhaust porting. During exhaust porting, exhaust valve 30 is open to allow fluid communication between the interior of tank 12 and balance pipe 34; motive valve 28, however, is closed to block fluid communication between motive pipe 32 and tank 12. It should be appreciated by one of ordinary skill in the art that various types of valves could be used for motive valve 28 and exhaust valve 30.

[0045] At the beginning of the liquid filling phase, liquid will begin flowing into tank 12 when the pressure is sufficient to overcome the pressure drop across check valve 41. If the pressure of the liquid is high enough, it will continue through check valve

42 and into return line 40. When the back pressure in return line 40 exceeds the pressure in the interior of tank 12, however, the liquid will begin to fill tank 12. As the level of the liquid rises, so does float 14. The positions of motive valve 28 and exhaust valve 30, however, do not change when float 14 is rising.

[0046] When float 14 reaches the high level position, as shown in Figure 1, the force of compression spring 22 rotates pivot member 24 in a snap over manner to its motive position. In other words, push rod 44 moves to simultaneously switch motive valve 28 and exhaust valve 30 in a snap over manner from exhaust porting to motive porting. During motive porting, motive valve 28 allows fluid communication between the interior of tank 12 and motive pipe 32. Motive gas thus introduced into tank 12 will force the liquid through liquid outlet 38 and into return line 40. Float 14 drops along with the level of the liquid within tank 12. The positioning of motive valve 28 and exhaust valve 30 remains the same, however, until float 14 reaches the low level position. When float 14 eventually falls to the low

level position, the pumping cycle will begin again. As used herein, the terms "low level position" and "high level position" are intended to indicate the float positions at which snap-over occurs. As one skilled in the art would recognize, these positions are approximately the same as, but not necessarily identical to the positional extremes to which the float will travel.

[0047] The pivoting operation of float arms 16 and pivot member 24 will now be described with reference to Figures 3 through 8. Each float arm 16 has a distal end with a lateral member 46 having a pivot element 48. Each such pivot element 48 includes a tip portion 49 received in a corresponding socket 50 defined in bushing 51. Bushing 51 is, in turn, fixed to support frame 18.

[0048] Accordingly, lateral members 46 of float arms 16 are pivotally connected to the rear of support frame 18 and may pivot freely within socket 50 of bushing 51. The small area of contact between the tip portions 49 of each pivot element 48 and bushing 51 provides minimal friction, thereby reducing failure of these components. It should be appreciated that pivot

elements 48 and bushing 51 may preferably be formed from high wear resistant materials, such as tungsten carbide or stainless steel.

[0049] Support frame 18 contains an opening 52 (Figure 8) through which pivot member 24 extends. As best shown in Figure 8, pivot member 24 contains a planar portion 54 on the float side ("front") of support frame 18. A pair of pivot elements 56 are carried by planar portion 54 of pivot member 24, as shown. Pivot elements 56 are each received in corresponding sockets 57 defined in bushings 51. As seen in Figures 6 and 7, pivot member 24 and float arms 16 thus pivot in oppositely-directed sockets of bushing 51, located respectively on the front and rear of support frame 18.

[0050] Referring again to Figure 8, a support member 58 also extends from each float arm 16 in the illustrated embodiment. Each support member 58 defines a tapered pivot point 60 (see Figures 4 and 5) that makes contact with and pivots with respect to support frame 18, thereby facilitating assembly of the pump and reducing lateral movement of float arms 16. An upper stop 62 and lower stop 64 (Figure 10) are

fixed to support frame 18 so as to limit the range of rotation of float arms 16, thus desirably restricting the range of movement of float 14.

[0051] Referring to Figures 11 through 13, compression spring 22 is disposed between a first anchor 66 and a second anchor 68. (In lieu of anchor 66, this end of compression spring 22 may be affixed to float 14 as shown in Figure 14). Spud 20 is operatively connected to first anchor 66 while planar portion 54 of pivot member 24 is operatively connected to second anchor 68 (see Figure 8).

[0052] Specifically, first anchor 66 and second anchor 68 define respective sockets 70 and 71 that receive tip portion 67 of spud 20 and tip portion 69 of pivot member 24. As float 14 moves between the low level and high level positions, tip portions 67 and 69 move within the respective sockets 70 and 71. The contact area between tip portions 67 and 69 and the corresponding socket 70 or 71 is relatively small, thereby reducing friction.

[0053] It should be appreciated that the engaging portions of spud 20, pivot member 24 and anchors 66 and 68 may preferably be formed from suitable high

wear resistant materials, such as tungsten carbide or stainless steel.

[0054] In some exemplary embodiments, anchors 66 and 68 may be provided with side walls to reduce lateral movement of the corresponding tip portion, which could cause them to become unseated from their respective sockets 70 and 71. As shown in Figures 16 through 18, for example, anchor 68′ has side walls 73 protruding from each side of socket 71′. Side walls 73 maintain tip portion 69 of pivot member 24 within socket 71′ of anchor 68 during pivoting.

[0055] In many embodiments, compression spring 22 may be held in place between spud 20 and pivot member 24 simply by its compression force. It should be appreciated, however, that anchors 66 and 68 may be connected to spud 20 and pivot member 24 using a pin or other suitable connection that allows the desired relative movement.

[0056] When float 14 reaches either threshold position, the force of compression spring 22 is sufficient to rotate pivot member 24 in a snap over manner about fulcrum 72 (pivot point about bushings as shown in Figures 6 and 7). When float 14 reaches the

high level position, pivot member 24 rotates to its motive position as shown in Figure 12. Pivot member 24 rotates to its exhaust position when float 14 reaches the low level position, as shown in Figure 11.

[0057] Pivot member 24 is pivotally connected to push rod 44 via a pin 74. The pivot point between pivot member 24 and push rod 44 is offset from fulcrum 72 by a predetermined distance such that rotation of pivot member 24 causes vertical movement of push rod 44 along its longitudinal axis. When float 14 reaches the low level position, push rod 44 travels in a first direction along its longitudinal axis (downward as shown in Figure 2). When float 14 reaches the high level position, however, push rod 44 moves in an opposite direction along its longitudinal axis (upward as shown in Figure 1). A guide 76 (Figures 6 and 7) may be provided to direct push rod 44 along a proper path.

[0058] Referring now to Figure 18, the relative distance between the engaging end of tip portion 69 and fulcrum 72 compared with the distance between pin 74 and fulcrum 72 can be configured to provide a mechanical advantage. In this illustrative

embodiment, for example, the distance between the engaging end of tip portion 69 and fulcrum 72 is designated as "A." The distance between pin 74 and fulcrum 72 is designated as "B." Because the distance "A" is greater than distance "B," less force can be applied on the engaging end of tip portion 69 to move pin 74. This permits the use of a "lighter" spring than may otherwise be required.

[0059] Preferably, the various tip portions and their corresponding sockets will be sized to facilitate relative movement and minimal friction therebetween. As shown in Figure 19, for example, tip portion 69 has a radius designated R2 while the radius of socket 71′ of anchor 68′ is designated as R1. By way of another example in Figure 20, the radius of tip portion 49 is designated R4 while the radius of the socket of bushing 51 receiving tip portion 49 is designed as R3. It can be seen that the radius R1 is greater than the radius R2 to allow pivotal movement between pivot member 24 and anchor 68′. Likewise, the radius R3 is greater than the radius R4 to allow pivotal movement between bushing 51 and pivot element 48.

[0060] Preferably, tip portions 49 and 69 have as small of a radius as possible while preventing possible breakage of tip portions 49 and 69. In one preferred embodiment, R1 has a range of approximately 0.047 inches to 0.063 inches while R2 has a range of approximately 0.030 to 0.047 inches. In another exemplary embodiment, R3 has a range of approximately 0.047 inches to 0.063 inches while R4 has a range of approximately 0.030 to 0.047 inches. Accordingly, the small radius of tip portion 69 will reduce friction between pivot member 24 and anchor 68′, thereby increasing the life of both anchor 68 and pivot member 24. Likewise, the small radius of tip portion 49 will reduce friction between pivot element 48 and bushing 51, thereby increasing the life of both pivot element 48 and bushing 51.

[0061] Referring again to Figures 1 and 2, push rod 44 is attached to an actuator plate 78, such that movement of push rod 44 also moves actuator plate 78. One of ordinary skill in the art should recognize that push rod 44 and actuator plate 78 can be constructed as a unitary member, or can be two pieces that are connected together or that otherwise move in unison.

[0062] As shown, actuator plate 78 is connected to both motive valve 28 and exhaust valve 30. Thus, movement of actuator plate 78 controls the porting of motive valve 28 and exhaust valve 30. As seen in Figure 2, motive valve 28 is closed and exhaust valve 30 is open when actuator plate 78 rests on stop 80. However, motive valve 28 is open and exhaust valve 30 is closed when actuator plate 78 is in the elevated position shown in Figure 1. Stop 80 limits downward movement of actuator plate 78 while upward movement is limited by exhaust valve 30.

[0063] A damping system 82 may be provided to reduce impact forces of opening and closing valves 28 and 30. In this embodiment, damping system 82 includes a plate 84 rigidly connected to pivot member 24. The drag caused by movement of plate 84 through the liquid in tank 12 slows movement of push rod 44. As a result, impact damage on the sealing surfaces of valves 28 and 30 is largely eliminated. Moreover, damping system 82 reduces the sound level of pump 10 in operation.

[0064] As shown, a pair of shafts 86 connect plate 84 to pivot member 24 in this embodiment. It should

be appreciated, however, that a single shaft or other suitable connector could also be utilized to attach plate 84 to pivot member 24. Moreover, embodiments are contemplated in which plate 84 and pivot member 24 are constructed as an integral member.

[0065] As also shown in Figures 1 and 2, a magnet 88 may be located within tank 12 to attract ferrous oxides suspended within the liquid. As a result, the presence of harmful debris within tank 12 is greatly reduced.

[0066] Further details regarding the operation of the compression spring mechanism will now be described with reference to Figures 1-2 and 11-13. As liquid begins flowing into tank 12, float 14 rises. The movement of float 14 causes tip portions 67 and 69 to rotate within the respective sockets 70 and 71 of anchors 66 and 68. However, pivot member 24 will not rotate to its motive position until float 14 reaches the high level position. Thus, the position of motive valve 28 and exhaust valve 30 also remains the same.

[0067] When float 14 reaches the high level position, the force exerted upon pivot member 24 by compression spring 22 is sufficient to rotate pivot

member 24 in a snap over manner to its motive position as shown in Figure 12. The rotation of pivot member 24 moves push rod 44 upward along its longitudinal axis. In the motive position, as seen in Figure 1, actuator plate 78 is elevated, thereby placing motive valve 28 in an open position and exhaust valve 30 in a closed position. Motive valve 28 thus allows fluid communication between the interior of tank 12 and motive pipe 32 (while exhaust valve 30 prevents fluid communication between balance pipe 34 and tank 12).

[0068] As liquid exits tank 12, float 14 falls with the liquid level within tank 12. The movement of float 14 causes tip portions 67 and 69 to rotate within sockets 70 and 71 of anchors 66 and 68. However, pivot member 24 does not rotate to its exhaust position until float 14 reaches the low level position. Thus, the position of motive valve 28 and exhaust valve 30 also remains the same.

[0069] When float 14 reaches the low level position, the force exerted upon pivot member 24 by compression spring 22 is sufficient to rotate pivot member 24 in a snap over manner to its exhaust position as shown in Figure 11. The rotation of pivot

member 24 moves push rod 44 downward along its longitudinal axis. In the exhaust position, as seen in Figure 2, actuator plate 78 rests on stop 80, thereby placing exhaust valve 30 in an open position and motive valve 28 in a closed position. Exhaust valve 30 thus allows fluid communication between the interior of tank 12 and balance pipe 34 (while motive valve 28 prevents fluid communication between motive pipe 32 and tank 12). When liquid filling tank 12 causes float 14 to reach the high level position, the pumping cycle will begin again.

[0070] An alternative embodiment is schematically illustrated in Figure 15. In this embodiment, the pivot sockets of bushing 51 are rotated approximately 90 degrees in comparison with the previous embodiment. The operation of this embodiment is otherwise substantially the same as that described above.

[0071] An alternative connection between float 14 and float arms 16 is shown in Figure 22. Instead of a rigid connection, float 14 is pivotally connected to float arms 16 to allow some free movement of float 14. Such an articulated connection minimizes the physical travel of pivots and anchors, but still achieves the

same stroke or swept volume. In the embodiment shown, float arms 16 have a U-shaped extension 90 to which float 14 is connected. A projection 92 extends from float 14 and has a hole that is aligned with a hole in extension 90. A pin 94 is placed through holes in extension 90 and projection 92 to form a pivotal connection. In some embodiments, stops 96 may be provided to limit the range through which float 14 can pivot. It should be appreciated that other suitable pivot arrangements could be used to connect float 14 and float arms 16.

[0072] It can thus be seen that the present invention provided an improved spring actuated mechanism for use with a gas pressure driven pump. It has been found that the use of high wear resistant materials, such as tungsten carbide, extends the life of components to over three million cycles.

[0073] One skilled in the art will also appreciate that the compression spring linkage of the present invention could be utilized in various applications other than a gas pressure driven pump. In such applications, the mechanism could be operated by

various devices and mechanisms (e.g., by hand, float, electric, pneumatic, etc.).

[0074] It should also be understood that aspects of the various embodiments may be interchanged both in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to be limitative of the invention described in the appended claims.